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WEATHER NOTE

Record 12- and 24-Hour Deepening Rates in a Tropical Cyclone

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ABSTRACT—On Nov. 10–11, 1971, 12- and 24-hr reductions of central sea-level pressure of 6.2 and 4.0 mb/hr, respectively, were recorded in typhoon Irma by aircraft reconnaissance. These are considered to be record deepening rates as compared to the previous extremes set by typhoon Ida (September 1958). The validity of the pressure readings is noted, and other observations in the eye region are discussed and compared with features characteristic of deep typhoons.

During the period from 1527 GMT on Nov. 10, to 1555 GMT on Nov. 11, 1971, successive sea-level pressure readings in the eye of typhoon Irma dropped from 981 to 884 mb. This extreme rate of deepening of 97 mb in 24½ hr, or an average of 4.0 mb/hr (95 mb/24 hr), is believed to be a record for a tropical cyclone. Previously, typhoon Ida, which deepened 86 mb during a 22½-hr period, or an average of 3.8 mb/hr (91 mb/24 hr) from Sept. 22 to Sept. 23, 1958, was regarded at the Joint Typhoon Warning Center (JTWC) as the record (Jordan 1961).

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The measurements recorded in typhoon Irma were obtained by dropsonde from the 700-mb level by U.S. Air Force WC–130 aircraft of the 54th Weather Reconnaissance Squadron while the typhoon was traversing the central Philippine Sea (fig. 1). The dropsonde soundings were recomputed by the quality control section at the 54th Weather Reconnaissance Squadron, Guam, Marianas Islands, and the National Weather Records Center, Asheville, N.C., and found to be hydrostatically consistent. A check using an empirical relationship developed by Jordan (1957) between the minimum 700-mb height and

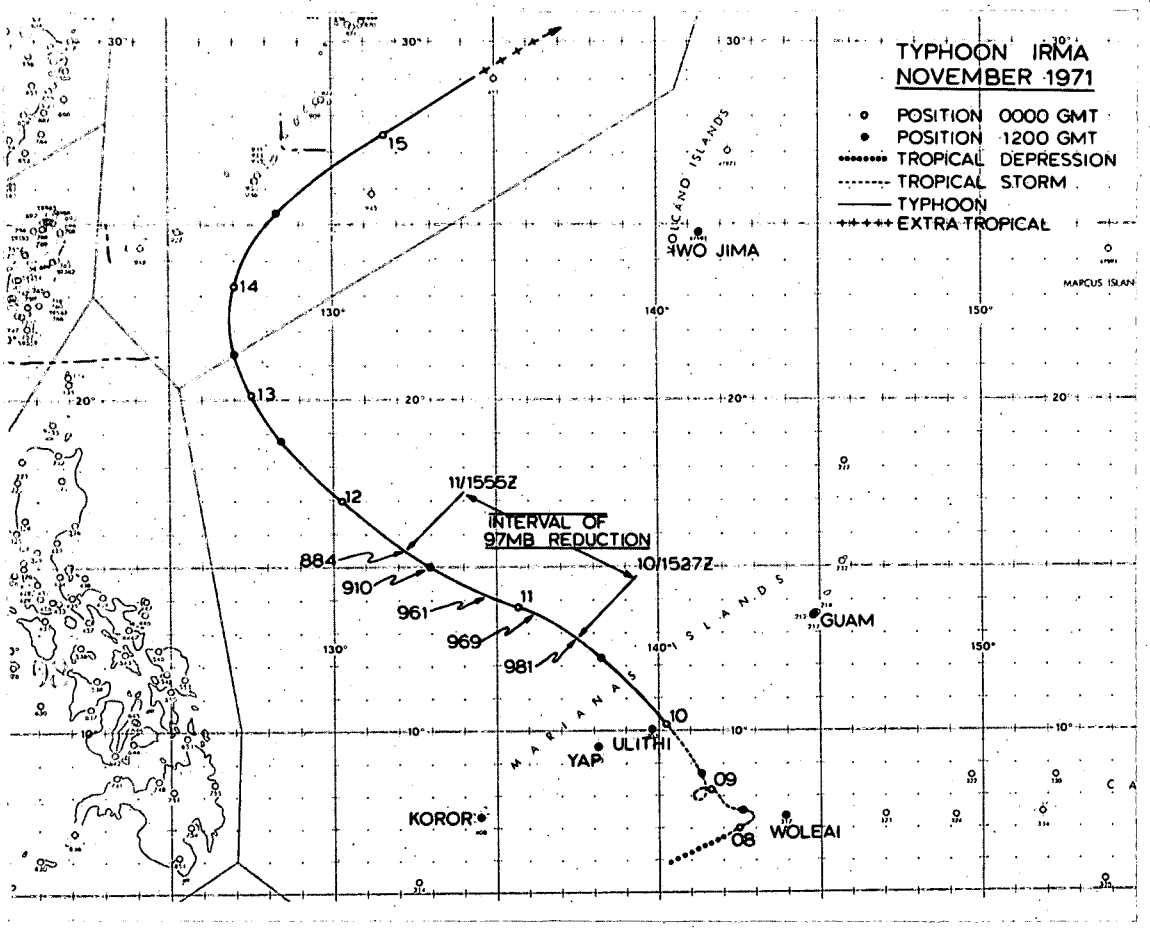

FIGURE 1.—Track of typhoon Irma during the period Nov. 7–15, 1971.

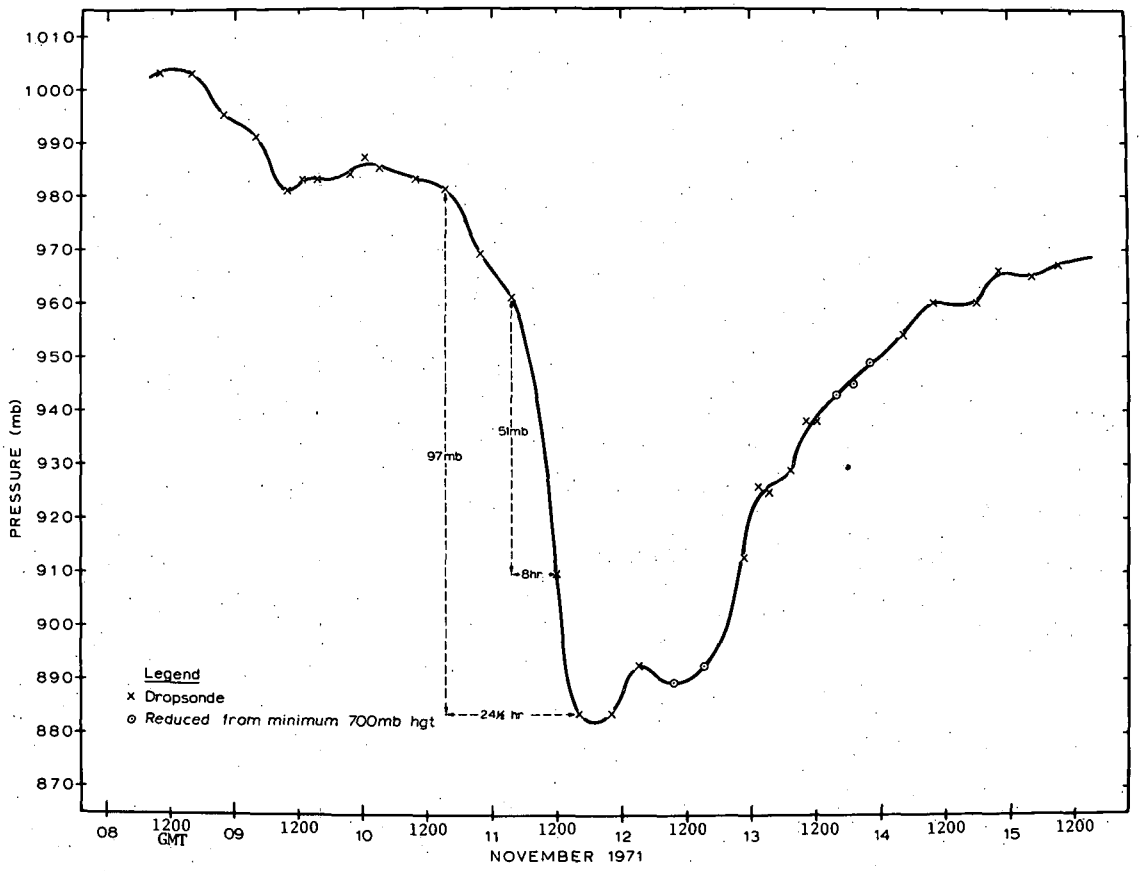

FIGURE 2.—Central sea-level pressures in typhoon Irma, reported by reconnaissance aircraft for Nov. 8–15, 1971.

the sea-level pressure in the eye also reaffirms the validity of the dropsonde readings.

Figure 2 shows the sea-level pressure history of Irma from November 9 through November 14. Deepening began at 1527 GMT on November 10, followed by an extreme drop between 0340 and 1155 GMT on November 11, a pressure fall of 51 mb in 8 hr or 6.3 mb/hr. During the 12-hr period from 0340 to 1555 GMT on November 11, sea-level pressure fell 77 mb or 6.4 mb/hr. This exceeds the 60 mb/14 hr pressure fall recorded in typhoon Ida (approx. 51 mb/12 hr, which is equivalent to 4.3 mb/hr).

Aircraft reconnaissance descriptions of the eye region prior to and during the period of most rapid deepening were illustrative of the marked changes that took place. The aircraft that penetrated Irma at 0340 GMT on the afternoon of November 11 observed the eye region to be filled with altostratus and stratocumulus clouds, while light, continuous precipitation was occurring at flight level (700 mb). The eye was depicted on the aircraft's 3-cm radar to be 15 n.mi. in diameter with the eye wall open in the south and southeast quadrants. Maximum temperature measured in the eye was 18°C, and the central pressure was 961 mb.

A marked change occurred during the subsequent 8 hr (fig. 3), before a second aircraft entered Irma after dark. When the second aircraft penetrated the eye wall, lightning was observed with such frequency that the state of the sea was visible below the wall cloud from the 700-mb level. On traversing the wall cloud, the aircraft encountered moderate turbulence and rain, and a drop of some 3,700 ft occurred in 30 s as the aircraft flew along the 700-mb pressure surface. The eye was closed and its diameter had shrunk to 6 n.mi., while frequent lightning in all quadrants illuminated steep and well-defined wall clouds encircling the typhoon's central eye region. The eye had cleared of middle clouds, leaving stratocumulus below and stars visible above. This clearing of the eye is consistent with the findings in Jordan's (1961) study of characteristics of intense typhoons during the deepening stage. A dropsonde measurement of 910 mb was recorded at 1155 GMT on November 11, while the maximum 700-mb temperature had warmed 3° to 21°C.

The same aircraft penetrated the storm again 4 hr later. The aircraft's radar showed that a concentric eye had formed, with the inner eye 7 n.mi. in diameter and the outer eye 40 n.mi. in diameter. A drop of some 4,000 ft occurred in 30 s on the second traverse of the eye wall. The formation of the double-eye phenomena has been documented by Fortner (1958), Jordan and Schatzle (1962), Hoose and Colón (1970), and others. This feature was noted in each of the cases to appear at a time near maximum intensity of the tropical cyclone.

The dropsonde released in the eye at 1137 GMT recorded a minimum sea-level pressure of 884 mb, and a further rise of 2° (to 24°C) in the maximum temperature at flight level (700 mb) was noted. The measurement of 884 mb in Irma ties with that in Joan of 1959 as the third lowest pressure recorded in a tropical cyclone.[2]

[2] Minimum sea-level pressures of 877 and 883 mb were recorded in typhoon Ida of 1958 and typhoon Nina of 1953, respectively.

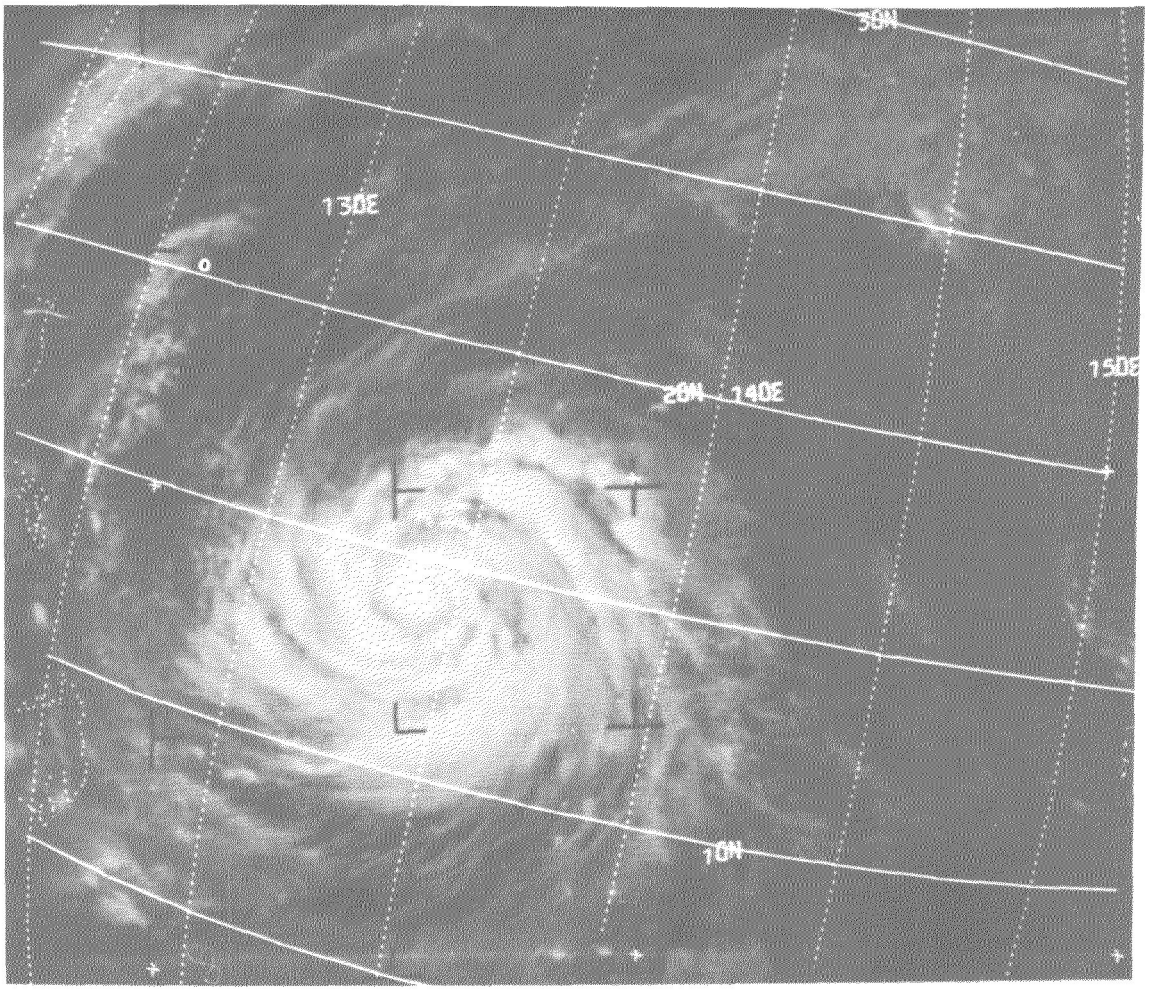

FIGURE 3.—Typhoon Irma as seen by ESSA 9 satellite at 0522 GMT, Nov. 11, 1971.

Another aircraft penetrating typhoon Irma 6 hr later recorded a minimum sea-level pressure of 884 mb and a maximum 700-mb temperature of 26°C, some 4°C above Jordan's (1958) mean for very deep tropical cyclones, but still 4°C less than the maximum attained by Ida.

In summary, the extreme deepening of 97 mb in 24½ hr in typhoon Irma was well documented by dropsonde measurements, and subsequent checks attested to the validity of the measurements. Reconnaissance aircraft observations, both visual and radar, were consistent with phenomena recorded in other cases of marked deepening in tropical cyclones.

The most dramatic sequence of measurements occurred during the 12-hr period between 0340 and 1555 GMT on November 11 in which 81 percent of the total deepening, 77 mb or 6.2 mb/hr, occurred. The dramatic reduction of central sea-level pressure overshadows the estimated drop of 51 mb in Ida, which occurred in an equal time interval. This explosive and phenomenal rate of deepening in Irma exceeds that of its closest rival, Ida, and, thereby, establishes a record for a tropical cyclone. The rarity of such an event is further illustrated by the measured minimum sea-level pressure of 884 mb, a value that has been surpassed by only two other typhoons on record.

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